# Visit of Mr. Christian DIDIER
# in INDIA

## BIHAR, WEST BENGAL ,UTTRANCHAL

**From 18th to 25th November 2002**

## Executive summary

This mission was very short time and speed in all states, therefore I have had just few discussions with the responsible of AEZ. Nevertheless we have visited numerous orchards and some nurseries.

Discussions with various participants in research, (Dr S. MITRA in West Bengal, DR M. RAI and S.B. KUMAR in Bihar, and Dr G. KUMAR in Uttranchal) growers owners, exporters, as well as extensionists (1 in West bengal, none in Bihar and 3 in Uttranchal), about the orchards and nurseries management.

At this time, some owners or nurserymen are collecting the planting material from mother trees selected during the last season (June), with selected true type.

This was found in the three states, more especially in Uttranchal.

I repeat the mains objectives:

1 To help the nursery owners to increase their yield in quantity as well as in quality in order to participate in a sustainable production system. Access to improved techniques of multiplication will allow to supply "Elite" plants.

2 To increase the varieties potential by introduction of early and late varieties from overseas. Screening in existing orchards to make a selection among the best cultivars in Bombay, Shahi, Rose Scented.

3 To promote access to, and the use of, good quality fruit trees by the growers.

4 To improve lychee cultivation by promoting production techniques and management systems of lychee trees in a sustainable manner.

5 To help regularly the lychee growers, it is necessary each AEZ will have 3 to 4 extension officers, this the angular stone for increasing lychee productivity. Identification of extension officers or NGOs.

6 To train the extension officers in relation with Research Centre or Universities if these want to participate actively to this project.

7 Identifications of growers and growers groups.

8 Setting up the demonstrations blocks: soils analysis, irrigation, fertilizer management, pruning, rejuvenation, IMP program.

9 Packing house and post harvest management will be done properly.

This project can run easily if all the recommendations are followed. I am hopefully for this.

## BIHAR Region Orchards Situation

| Request | Done | To Do | Observations |
|---|---|---|---|
| **Lychee selection** (on farm) | Started by research. | Should be continuous. | This work should be done year after year. |
| **Germplasm** (on station) | | | The research station is still in May, nothing has been done. Introduction of exotic material should be done this year. |
| **Phenological survey** (on farm) | | Should be started since the new flush (panicle appears in January). | It was more interesting if these observations have started after pruning. |
| **Pests and diseases** (on farm and in station) | Some treatments against pests, but sometime with bad chemical or chemical mixed with some other equal injuries on the leaves. | Make some investigations to know the pest and ecology to make the good treatments at the right time. | At this time the research centre for lychee is theoretically based in Muzafarpur and all the investigations have to be done at soon. |
| **Fertilization trials** (on farm) | Only the normal application has been done. | Following the productions of the trees, applied the best fertilization. | None has been done. |
| **LEAF ANALYSIS** | No. | To control the fertilizer application. | I hope some will be done after blossom. |
| **Growth regulator** (on farm and on station) | Yes with Cultar applied on the ground in November by private exporter following the result obtained in Patnagar university. | | All the trees will be followed regularly to know the advantage or the disadvantage of this application. |
| **Pruning** | Done in the majority of orchards. | | |
| **Irrigation system** | Unfortunately some irrigations continuous in November. | Applied schedule. | Since October to the fruits setting the irrigation should be stopped. |

| EXTENSION ACTIVITY | | | |
|---|---|---|---|
| **Request** | **Done** | **To Do** | **Observations** |
| **Identification of extension officers** | May be but I did not see the extensions officers just one farmer plays this role. Dr Kumar (ACIAR) does this work for some farmers groups. | | During my last mission in May the agriculture Department said 2 or extensionists will be given for this project. |
| **Training of the extension officers** | | Should be done when the extension officers will be found. | |
| **Identification of growers and growers groups** | Is done under the supervision of the exporters. Dr Kumar ACIAR follows some farmers. | | Kedia supports 38 farmers (10 000 trees).<br>Pamaragro supports some farmers. |
| **SURVEY on lychee Orchards** | Not yet. | Should be done to know the situation and the orchards place. | |
| **Demonstrations blocks** | I found some. | Necessary to have more to train the farmers. | |
| **Rejuvenation** | Some done by Dr Kumar. | | Should be done at the good height. |
| **IPM program** | Not yet | | |

## WEST BENGAL Region Orchards Situation

| Request | Done | To Do | Observations |
|---|---|---|---|
| **Lychee selection** (on farm) | They said yes, but unfortunately, I did not see the nurseries. | | |
| **Germplasm** (on station) | | | Exist in Calcutta in research centre, but I have not time to visit. |
| **Phenological survey** (on farm) | | Should be started since the new flush (panicle appear in January). | To know the different stage of the tree following the season and applied good management. |
| **Pests and diseases** (on farm and in station) | We made some training for the farmers in Malda about the pests found at this time (Nov). | Should have a good cooperation with the research centre in Calcutta. | |
| **Fertilization trials** (on farm) | Normal application of fertilization without trials. | Following the productions of the trees, applied the best fertilization. | |
| **LEAF ANALYSIS** | No. | | |
| **Growth regulator** (on farm and on station) | No. | | |
| **Pruning** | Was done in some orchards. | | |
| **Irrigation system** | Some progress are going on. | | |
| **EXTENSION ACTIVITY** | | | |
| **Identification of extension officers** | Same in May only one dedicated for lychee and mangoes. | It will be better if one more exists, because a lot of progressive farmers needs training. | The Director of Agriculture is all time present on the fields to help the extensionist. |
| **Training of the extension officers** | No. | Should be done by the research center. | |
| **Identification of growers and growers groups** | Yes in Malda. | | |
| **SURVEY on lychee Orchards** | Not yet. | | |
| **Demonstrations blocks** | Some blocks are dedicated for that. | | Registration book is available in these demonstrations blocks. |
| **Rejuvenation** | Not yet. | | |
| **IPM program** | Not yet. | | |

## UTTRANCHAL Region Orchards Situation

| Request | Done | To Do | Observations |
|---|---|---|---|
| **Lychee selection** (on farm) | Is done. | | New nurseries are started with these selections (Chada, Babil garden, Patnagar university and governmental nurseries). |
| **Germplasm** (on station) | | | Theoretically in Patnagar University. |
| **Phenological survey** (on farm) | Not yet. | Should be done to know the different stages of the trees. | |
| **Pests and diseases** (on farm and in station) | Survey is started. | | In collaboration with entomologist of Patnagar university. |
| **Fertilization trials** (on farm) | Normal application. | Following the productions of the trees, applied the best fertilization. | |
| **LEAF ANALYSIS** | | | |
| **Growth regulator** (on farm and on station) | | | Some results exists in University, should be transfered to the farmers. |
| **Pruning** | Has been done in some farms. | | |
| **Irrigation system** | A lot of progress in demonstrations farms. | | |
| **EXTENSION ACTIVITY** | | | |
| **Identification of extension officers** | 3 young extensions are present. | | |
| **Training of the extension officers** | Training of these is started but should be continuous with Dr G. Kumar | | Should be done on the fields by scientists identified by there know ledges on lychee. |
| **Identification of growers and growers groups** | Yes in different regions. | Registrations books will be started for all farms especially for the news orchards planted this year (100 ha). | |
| **SURVEY on lychee Orchards** | Started for some. | | Important to know the orchards. |
| **Demonstrations blocks** | Some blocks are dedicated for that. | | All information will be mentioned in registration book. |
| **Rejuvenation** | Not especially rejuvenation, but severe pruning has been done. | Some old orchards need this technique. | |
| **IPM program** | Not yet. | | |

**Fertilization**

**It has been established, that the harvest of 100 kg of lychee fruits removes approximately:**

| N | P | K | Ca | Mg | Fe | Mn | Zn |
|---|---|---|---|---|---|---|---|
| 240 | 34 | 240 | 39 | 34 | 3,0 | 0,30 | 0,45 |

The application of fertilizer should correspond to the different needs of the tree at various stages of the growth cycle. Critical periods are before flowering and fruit set. The application of fertilizer should correspond to the different needs of the tree at several weeks after fruit set and after harvest.

**For next season follow this:**

**SCHEDULE**

**Seasonal guide for lychee production in adult's orchards.**

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil sampling** | | | | | | X | X | X | | | | |
| **Leaf analysis** | | | | | | X | X | X | | | | |
| **Plough the orchard Cover crop** | | | | X | | | X | | X | X | | |
| **Irrigation** | | | X | X | X | X | | | | | | |
| **Fertilization** | | | X | | | X | X | | | | | |
| **Control of pests** | X | X | X | X | X | X | X | X | X | X | X | X |
| **Manuring** | | | | | | X | | | | | | |
| **Pruning** | | | | | | X | | | | | | |
| **Weed control** | | | | X | | | X | | X | X | | |
| **Harvesting** | | | | | X | X | | | | | | |

## January

- **Do not fertilize and irrigate the adult's orchards.**
- Irrigate the young plants and protect them against cold.
- Control the leaf curl mite ( *Aceria lychee*/erinose):
  - Prune and burn the affected twigs infested or treatment with:
    - i wettable sulphur (microlux or thiovit) : 500g in 100 l water,
    - ii Kelthane (dicofol) 480 g/ha = 120 ml/100 l water.
- Control the leafs miner ( *Acrocercops heirocosma* and other):
  - Spray 0.05% endosulfan 2.0 ml/1 l water.
- Control of shoot borer, the treatment against leaf miner can reduce the population of shoot borer.

## February

- Remove thatches around and above the younger plants and irrigate them.

## March

- Control of mites and shoot borer (sea above) very important.
- Transplant the new plants in orchard into already prepared pits and irrigate them immediately.

## April

- Control of fruit borer: lychee moth (Cryptophlebia illipida). The following treatments are recommended:

  One month before harvest:
  - fenthion (Lebaycid 170 cc/100 l water),
  - deltamethrin (Decis 80 ml/ 100 l water).
- Control of mites and shoot borer (see above) very important.
- After the fruits set start irrigation in adult's orchards.
- Apply nitrogen (ammonium sulfate or urea) and potassium sulfate after the fruit setting in the rate following the leaf analysis result.
- If boron deficiency spraying of 1% borax solution on trees by month-end.

## May

- Control of mites and shoot borer(see above) very important.
- Controls of fruit borer (Cryptophlebia illipida) (see above).
- Irrigate the orchard at approximately every 10 days to maintain > 75-80% relative humidity in the orchard.
- Lay out, digging and filling quickly of pits for new orchard plantation in June or July.
- Start harvesting when the fruit TSS reaches at 17-18%. Careful handling of fruit is necessary. Avoid skin desiccation during all operations.
- Start to prune the harvested trees, and apply the nitrogen, potash, phosphorous and manure.

## June

- Control of mites and shoot borer (see above) very important.
- Harvesting as mentioned above.
- Irrigate the orchard to maintain 75 to 80% relative humidity.
- Prepare the air layering.
- Lay out, digging and filling quickly of pits for new orchard plantation in June or July.
- Control Shoot and bark borers by putting "endosulfan" or petrol in the holes and plug them with mud.
- Prune the trees, and apply nitrogen, potash, phosphorous and manure.
- Prepare air layering.
- Irrigate young plants.
- Subsurface tillage (maximum 15 cm deep) the orchard for to bury green manure (weeds).

## July

- Control of mites.
- Make air layering throughout the month as when the weather permits.
- Irrigate the young plants if rainfall is not efficient.

## August

- Control of mites.
- Separate the air layering from the mother plants and transfer to the nursery.

## September

- Control of mites.
- Irrigate newly planted orchards, if necessary.
- Transplant one-year-old plants of nursery in the pits and irrigate them.
- Separate the rooted air layers (of July) from the mother plants and transfer to the nursery.

## October

***Zinc (Zn) and Boron (B) sprays***

Since most soils naturally contain little zinc or the zinc is not available, this element must be applied at least four times a year. The following substances and concentrations are recommended for 100 l of water.

Zinc oxide at 200 g or Nitro-Zn at 150 mg or Agri-zinc at 50 mg.

Many orchards also display low boron values and from the outset the trees should be sprayed with 100 g borax or 75 g Solubor/100 l water every 2 years.

- Control mites.
- Leaf analysis and look at the deficiency.
- Subsurface tillage (maximum 15 cm deep) the orchard for to bury green manure (weeds).

## November

- Control mites.
- Irrigate the young plants.
- Prepare thatches to cover the young plants in the orchards as well as in the nursery for protection against frost (Uttranchal).

## December

- Water young plants as and when needed to keep the soil wet and protect the plants from frost.

# POST-HARVEST HANDLING OF LYCHEES

Post-harvest handling operations for lychees (Litchi chinensis Sonn.) are relatively simple and result in high-quality fruits that can be exported. Harvest maturity, prevention of mechanical damage, cooling, and temperature maintenance are critical factors that, when optimised, can allow for storage and shelf-life of as long as more than six weeks.

## Quality Criteria

Import markets require lychees to be fresh in appearance, free from blemishes and mechanical damage to the skin, with uniform red colour. Minimum size should be a diameter of 2.5 centimetres, length of 3.0 centimetres, and weight of 20 grams.
The pulp (or aril) should be easily removable from the seed coat and make up at least 75% of the weight. Cultivars that have little aril or aril that remains stuck to the seed are normally not acceptable. The aril should be translucent and sweet with a Brix level of around 17 ° to 19 °.

## Cultivars

Acceptable cultivars are those that meet market quality criteria and offer growers good yields, adaptability, and disease resistance.

Lychee cultivars grown are highly variable under different agro-climatic conditions. More than 20 cultivars have been described in India, but only a few are of commercial importance. Cultivar names can cause confusion because the same cultivars may have different names in different regions. Cultivar selection has been based on performance under specific production conditions. i.e. Shahi, China, Calcuttia, Early Bedana, Late Bedana and Longia. (H.P. Singh).

Indian cultivars vary greatly in vegetative fleshing pattern, flesh colour and flowering ability. Based on these characteristics, cultivars were classified in five groups **(H.P. Singh)**.

Group A: Deshi, Shahi, Rose Scented, Dehradun, Ajhauli

Group B: China, Calcuttia, Purbi, Manraji

Group C: Kasba

Group D: Late and early Bedana, Swarna Rupa, Seedless

Group E: Longia

**Varietal distribution of lychee in different states in India (H.P. Singh).**

| States | Varieties |
|---|---|
| Bihar | Desi, Purbi, China, Kasava,early and late bedana, Dehra Rose, Shahi, Madrazi, Maclean, Longia, Kasailuya, Ajhauli, Kaselia, Turkolins |
| Uttranchal, Uttar Pradesh | Early large Red, Early and late Bedana, late Large Red, Shahi, Rose Scented, Calcuttia, Extra Early Green, Gulabi, Pickling, Khatti, Dehradun, Piazi. |
| West Bengal | Bombai, Elaichi Early, China, Desi Purbi, Kasba |

*C. M. Menzel, Australian breeder mentioned for India three cultivars: Shahi, Rose-Scented and China.*

New cultivars being developed and should be introduced in India:

- Kwai May Red: More important variety in Indian ocean.
- Souey Tung: An early cultivar planted in the cool, dry areas of Australia.
- Haak Yip: A cultivar with a long harvesting period, suitable mainly for processing.
- Kwai May Pink: A late cultivar with a long harvesting period.
- Salathiel: A small tree with attractive skin colour and small seeds.
- Wai Chee: A cultivar with a long harvesting period but poor tree structure (the most common cultivar in China).

**Harvest Maturity**

Lychees achieve maturity between 100 and 110 days after pollination, at which point the fruits weight is around 20 grams.

Although climatic factors influence the time of flowering, they do not necessarily affect fruit development or maturity.

Harvesting takes place at four to five weeks, depending on the cultivar, production area, and conditions.

Because lychees are non-climacteric and stop maturing when harvested, the quality, colour, and flavour are determined at harvest time. The stage of maturity at harvest is therefore critical in determining consumer acceptability. Immature lychees have poor skin colour and are acidic, not sweet. **Lychees should be harvested in the morning or late afternoon when ambient temperatures are lower**; harvesting during hot periods can speed up the rate of water loss. Harvesting is carried out every two to three days and is based on fruit maturity, especially during the early part of the season. Yet not all fruits on a tree mature at the same time; even fruits on the same panicle do not mature uniformly.

Optimum maturity can be judged by the following:

- **Fruit weight**: Ripe fruits average 21 grams to 25 grams in weight.
- **Fruit colour**: Ripe fruits are red on both the outer and inner surface of the skin.
- **Time from pollination**: Normally 100 to 110 days elapse before maturity.
- **Sugar and acid contents**: During ripening on the tree, the acid content of the aril decreases, and the sugar content increases: acid ranges from 5.5% to 0.5%, and sugar ranges from 10% to 17%. Fruits with an acid content of 0.9% taste sour, whereas those below 0.4% tend to be bland because of a sugar and acid imbalance.
- **Skin texture**: With some cultivars, maturation can be detected from the skin, which becomes smoother as the small protrusions become flatter.

**Harvesting**

Harvesting can be done using, pruning shears or handling to remove panicles, each containing 4 to 20 fruits, from the tree.

Where harvesting is carried out from the ground, the bunches are placed into plastic field crates. Where ladders are used, the picker places the bunches into a cotton bag that is regularly lowered to the ground and transferred to field crates.

When picking tools are used to cut the panicles, a bag should be attached to the pole so the fruits do not fall to the ground. A blade, knife, or pruning shears form a part of the tool to cut the main stem of the panicle; to avoid breaking the fruits' skin, the fruit should not be pulled from the bunch.

On arrival at the packing facility or on the fields fruits should be cleanly clipped from bunches, with 0.5 centimetres of the stem left attached. Fruits that are brown or not uniform in colour, are undersized, show any damage or disease, or have cracking skin should be rejected at this point. Fruits infested with fruit fly or lychee moth begin fermenting within a day as a result of secondary fungal infection.

For transportation from the field to the packing facilities, use only plastic field crates. Field crates should be shallow, light coloured, ventilated, and clean. Damage to fruits frequently occurs during these handling operations from dropping, excess weight on top of the fruits, and rubbing of the fruits against one another or against the container. Damage results in increased water loss, which causes fruit to turn brown or black, thereby reducing shelf-life, appearance, and marketability. **To minimize increases in fruit temperature, crates should not be exposed to direct sunlight but be kept in the shade and loaded onto covered or protected vehicles for transportation**. Fruits wet from the rain should not be picked.

**Packinghouse Operations**

The simple operations for lychee grading and packing include trimming, pre-classifying, cleaning or brushing, fumigating (sometimes), packing, pre-cooling, storing, and transporting. The time between harvesting and packing should be kept to a minimum. The sooner the fruits are packed and cooled (or shipped) after harvest, the better their quality on arrival in the market. Delays between harvesting and packing are frequently the cause of water loss and diminished quality.

## SULPHITATION PROCESS

### $SO_2$ in the conservation of lychee

$SO_2$ is an anti-oxidant and blocks oxidation reactions by inhibiting polyphenol oxidase, thus preventing browning.

It forms a colourless complex with anthocyanins, causing loss of red colour, thus revealing the other pigments, especially carotenoids. The pericarp is then yellow to greenish yellow. It acidifies the pericarp cell content, contributing to the stabilisation of the fruits; it has an antifungal effect and reduces mould growth. The pericarp remains flexible.

### $SO_2$ treatment procedure

The fruits are fumigated with sulphur dioxide gas produced by burning sulphur in powder form; the latter reacts with the oxygen in the air to produce $SO_2$.

The quantity of $SO_2$ absorbed by the fruits depends on:

- the quantity of $SO_2$ in contact with a given mass of fruits,
- the duration of the treatment.

After treatment, the $SO_2$ absorbed by fruits stored in an unconfined atmosphere is gradually released; the process also depends on the storage temperature. The release of $SO_2$ enables the fruit to gradually recover a pale red colour; this is less bright than the original colour as part of the $SO_2$ remains chelated with anthocyanins.

As a result, for fruits to arrive in Europe in conformity with the French or European regulation (maximum 10 mg $SO_2$ per kg of pulp and 250 mg per kg of skin), the quantities of $SO_2$ or sulphur per tonne of fruits and the duration of treatment must be adapted to transport temperature and the time elapsing between treatment and sale. Thus, the amounts of $SO_2$ required for the shipping of litchi by air will be smaller than those used for sea transport. Treatment time will also be shorter.

Sulphur treatment is generally performed near export locations. The following operations must be performed as soon as possible after the delivery of the fruits to the processing station:

**First sorting and grading operation - Packing for sulphur treatment - sulphur treatment - second sorting operation packing - loading (ship or aircraft)**

### First sorting and grading operation

This is an essential factor for the quality of the fruits sold. The main quality criteria are as follows:

- sufficient ripeness but without excess (soluble dry extract 17 to 20%),
- minimum diameter 30 mm,
- no blemishes,
- the stalk must not be more than 5 mm long (so as no to wound other fruits) or have been removed,
- the fruits must be dry. If not, they will display burns caused by the formation of sulphuric acid following treatment.

Packing facilities should be arranged linearly and include a delivery table, grading and packing tables.

Lychees must be allowed to dry completely before packing and storage because moisture from either washing or condensation increases the fruits' chance of developing disease.

Acceptable fruits are placed on the delivery table and moved to roller brushes to be cleaned; the brushes should be soft and revolved slowly. The fruits are then placed on grading tables, which should be slightly sloped and protected with a sponge layer and a clear plastic covering. If a conveyor belt is used, the tables can be located on one or both sides of the belt.

### Packing for sulphur treatment

The fruits are placed in plastics boxes with ample perforations to allow the free movement of $SO_2$ gas.

It must be possible to stack the containers, which are filled to two-thirds of their capacity at most. The weight of the packed fruits is recorded.

## Sulphur treatment

### *Equipment*

Treatment is performed in a **sealed chamber** in a shady, airy place (the outside walls can be painted white to prevent strong heating). Old 20-foot containers are often used. The chamber must have a wide door, be fitted with two **fans**, one at the front and the other at the back. One of these is directed towards the floor and the other towards the roof to maintain a constant movement of heavier-than-air $SO_2$. If possible, the chamber is fitted with a shaft to remove residual $SO_2$ by means of a powerful extractor fan. $SO_2$ is produced by burning sulphur, burners are placed on the floor along the length of the chamber. Steel burners are used.

They are long (e.g. 1.5 m), 10 to 15 cm wide and 2 or 3 cm high; they are on legs about 5 cm high. Three burners are placed in a 20-foot container. Treatment time must be measured accurately.

Treatment is performed at ambient temperature.

*Loading the chamber*

To ensure satisfactory movement of gas, the boxes are piled on blocks and positioned at least 10 cm from the walls. A central aisle is left so that the burners can be set out and a fan placed at each extremity. The chamber must be filled to at least half and not more than two-thirds of its volume.

***Recommended sulphur dose and treatment duration*** (see table below)

If sulphur is used, the quantity required is divided between the three burners and placed on a layer of crumpled newspaper (to ensure that the powder burns well). The paper is lit, the door is closed hermetically, the fans are started and the time of the beginning of the operation is recorded. Continuous ventilation is required to ensure homogeneous treatment of the fruits. It would seem that continuous movement of the gas may somewhat reduce penetration of the pulp.

| Mode of transport | Quantity (grams) of sulphur required to treat 1 tonne of fruits | Duration of treatment (in minutes) |
|---|---|---|
| Sea | 600-650 | 50-60 |
| Air | 300-400 | 30 |

After the end of the treatment time, the residual $SO_2$ must be removed as quickly as possible. The chamber should be equipped with an extractor system, this is started and the door opened slightly. The chamber can be emptied. $SO_2$ is a toxic gas and the workers handling the fruits should wear masks.

The fruits should be yellow to greenish yellow. If they remain pink, the treatment cannot be resumed and the fruits cannot be exported. There can be several reasons for this:

- the chamber was not sealed,
- a mistake was made in treatment duration or the dosage of gas or sulphur,
- combustion was poor,
- a particular physiological state of the fruits induced incomplete reactions and the duration of treatment should be increased progressively in 5-minute steps.

**Any contact with moisture or rain must be avoided.** Handling and packing must be carried out in sheltered premises but the latter should be well-ventilated if possible to remove residual gas.

**Second sorting**

Any blemished fruits and those with brown spots ($SO_2$ burns caused by wet patches) or that are undersized are rejected.

**Control of the $SO_2$ content of fruits**

With good ventilation, the $SO_2$ content of pulp and pericarp decreases steadily in time. No more than the maximum levels of 10 and 250 mg $SO_2$ per kg should be observed on arrival of the fruits in France, but studies of the kinetics of $SO_2$ levels performed at departure using the simulation of transport make it possible to know the admissible levels. A standard $SO_2$ assay method (*Détermination de la teneur en dioxyde de soufre*; J.O. de la République Française, 7/11/1987, pp. 13003 and 13004) can be used for control in laboratories with the appropriate apparatus and competent staff.

**Packing**

Fruits should be completely dry before packing. Some markets require packing by size (normally medium and large), but others allow mixed sizes as long as the minimum size is met. It is essential to check with buyers to determine size and grading requirements.

Carton closures must allow good ventilation of the fruits for the following purposes:

- elimination of the $SO_2$ released gradually by the fruits; if not, the gas will tend to impregnate the pulp, where the level will increase while that of the pericarp displays little changes;

- prevention of excessive ambient moisture that would lead to condensation in the carton, which would become weaker, and on the fruits, causing acid burns and enhancing the development of moulds.

Lychees are placed one at a time into cartons, ensuring maximum use of space; forcing them into tight spaces will damage the skin. Carton net weights are 2 kilograms to 4 kilograms (more 5 to 8% to cover weight loss), depending on the requirements of the importing country and the buyer. Some markets prefer lychees prepacked in punnets. The weight and number of fruits per punnet depend on the market. Packing into these smaller units aids in presentation; reduces mechanical damage; and, in most cases, extends shelf-life.

Packaging is done in one carton that is self-locking and has a minimum breaking force of 10 Kg per square centimetre. Ventilation is required in all four walls. Narrow vertical ventilation is preferred because round vent holes become blocked by the fruits. If one-piece cartons are used, there should be a maximum of 2 centimetres between the lid and the fruit. Carton dimensions vary depending on the net weight and the market. The most common package size is 2 kilograms with external dimensions that are compatible with ISO pallets (100 X120 cm):

| **Dimensions in cm** | | |
|---|---|---|
| **Length** | **Width** | **Height** |
| 40 | 20 | 9 or 10 |
| 30 | 20 | 9 or 10 |

Packaging should meet all labelling requirements of the importing country, including: country of origin ; product, variety ; net weight; and exporter names.

Then the cartons are packed on palettes. They must be arranged in such a way as to allow good ventilation.

**Cooling and Storage**

If a cold chain can be maintained, the faster the fruits are cooled, the longer they will retain the quality they had when harvested. Unlike other tropical and subtropical fruits, lychees are not chilling sensitive and should be stored at temperatures of 0.5° C to 2 ° C, with 85% to 95% relative humidity. Fungal growth at this temperature is minimized, and the fruits retain their colour, texture, and flavour. The probability of browning increases when fruits are stored in low humidity.

Hydrocooling can be used to pre-cool the fruits, although normally it is preferable to use forced-air pre-cooling that will remove the field heat within two to three hours if vertical column palletization is used and carton ventilation is appropriate. After cooling, the pallets should be placed in a standard cold room. If normal cold-room cooling is used, the cartons should be stacked to enable air movement around each carton. Cooling in this manner can take between 8 and 12 hours.

**By air the same day, cooling and low-temperature storage are not recommended. The condensation that develops on removal from cold storage to hot ambient conditions is ideal for fungal growth, which exporters should not risk with fruits that will be shipped right away.**

**Loading**

All operations, including loading, must be carried out as rapidly as possible. Fruits transported by sea can be loaded in containers on the quay, loaded on the ship and chilled immediately using fan refrigeration equipment (2 to 3°C.) or loaded in refrigerated and ventilated holds in traditional vessels, whose hatches must be closed between each operation to prevent temperature changes that are harmful for fruit conservation. Optimal temperatures are rarely maintained in aircraft, but the short periods of time involved limit incidents.

**Transport**

Lychees are generally exported by air, although they may be shipped by sea if the cold chain is maintained. Transportation from the packing facility to the airport should be in cool trucks if the fruits have already been cooled. In all cases, trucks should be covered to prevent contact with wind, rain, and sun.

Air shipments are made in aircraft containers or aircraft pallets. Heat build-up in containers is possible, especially when left exposed to the sun in the airport while waiting for arrival and loading. Because heat is detrimental to the fruits, aircraft containers and pallets should be kept in the shade or in cool conditions until loading.

**Potential Post harvest Problems**

Fruit Cracking and Fruit Browning. A principal cause of losses in lychees is cracking during the ripening period. Cracking is caused by a range of factors, including lack of moisture or a nutrient deficiency during the initial stage of fruit growth, followed by high rainfall in the later stages. Insects and sunburn may also cause cracking.

Fruit browning is believed to be a process of early cell ageing and death. If it occurs during growth, the skin may crack where the cells are dead. Browning is not caused by insect damage or fungal diseases, but the following factors may be involved:

- nutrient imbalance,
- tension in the pericarp causing cell damage,
- exposure to high temperature and low humidity during growth.

**Diseases**

The post-harvest diseases of lychees are predominantly secondary infections that develop as a result of mechanical damage or through the cut stem of the fruits. These may include Aspergillus rot, Pestalotiopsis rot, Peronophythora rot, sour rot, Botryodiplodia, Colletotrichum, and Rhizopus. Disease control begins in the orchard, with measures against lychees moth insects. Careful handling, prevention of mechanical damage, and rapid cooling minimise secondary infections.

**Recommendations**

If exporters want to increase quantities, it is very important to reduce all handling by using modern practices, replacing balances by modern types and reduced handling in grading, fumigation and pre-cooling.

It would be essential to load lorry or sea containers as quickly as possible (so that no condensation occurs on the fruit). Palettization should therefore be used. Different pallets are required according to the container used.

Sea container requires pallets 1 x 1.20 m.